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A New Squalid Species of the Genus *Centroscyllium* from the Emperor Seamount Chain

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Abstract A new etmopterine species, *Centroscyllium excelsum*, is described from 21 adult specimens captured in the Emperor Seamount Chain, central North Pacific. The present species is distinguished from its congeners in having a very high and semicircular-shaped 1st dorsal fin with a developed spine, dermal denticles only on dorsal side of head and trunk, the 2nd dorsal spine arising behind pelvic fin base, a short caudal peduncle, and prefrontal wall and chondrified eye stalk on neurocranium. Ten embryos were collected from one of the female specimens, and some embryonic features are also noted.

The genus *Centroscyllium* Müller et Henle is a small but well-defined assemblage. Among etmopterines, these *Centroscyllium* species are strikingly characterized by upper and lower jaw teeth similar in form, with 2 to 4 distinct lateral cusps, arranged quincuncially; keel-process of basal cranii extending anteroventrally from suborbital region of neurocranium; subnasal stay at posterolateral edge of subnasal fenestra; and unpaired genio-coracoideus directly originating from the frontal surface of coracoid symphysis (Shirai and Nakaya, in press). According to Bigelow and Schroeder (1957) and Compagno (1984), *Centroscyllium* is currently represented by six species inhabiting deep-sea waters: *C. fabricii* (Reinhardt) from the western North and eastern Atlantic Ocean, *C. granulatum* Günther from the Falkland Islands, *C. ornatum* (Alcock) from the northern Indian Ocean, *C. nigrum* Garman from the Pacific coast of North and South America and Hawaii (*ruscosum* Gilbert has been recognized as a synonym of *nigrum*, but see discussion), and *C. ritteri* Jordan et Fowler and *C. kamoharai* Abe from the western North Pacific. Dolganov (1986) assigned his *sheikoi* to the genus *Centroscyllium*, but it must be more closely related to the genus *Etmopterus* (Shirai and Nakaya, in press).

Recently, we found 21 large *Centroscyllium* specimens from the Emperor Seamount Chain in the central North Pacific. They have a very high 1st dorsal fin and a unique pattern of dermal denticle distribution. These features are sufficient to recognize them as a new species, and it is described below.

Methods and materials

Methods for making external measurements follow Springer (1964) with several exceptions and additions as follows: origin of each dorsal fin is substituted by anterior point of emergence of each dorsal spine (see Krefft, 1968); distances from snout tip to nostrils and to mouth (preoral snout) are measured, parallel to body axis, to posterior edge of nasal pore, and to anterior edge of oral cleft respectively; pelvic fin length is from origin to free rear tip; length of each dorsal spine is from origin of the fin to spine tip. Head length (from snout tip to pectoral origin: HL) and precaudal length (from snout tip to upper caudal origin: PCL) are used throughout. Teeth are counted around the outer margin of each jaw. Vertebral counts are made from radiographs according to Springer and Garrick (1964): total number is subdivided into monospondylous, precaudal diplospondylous, and caudal counts. Terminology for internal characters mainly follows Edgeworth (1935), Holmgren (1940, 1941), and Gilbert and Heath (1972).

Institutional abbreviations follow Leviton et al. (1985) with an addition: TMFE (Department of Fisheries, Faculty of Marine Science and Technology, Tokai University, Shimizu). Type specimens of the species described herein have been deposited in HUMZ, CAS, NSMT, and USNM. Abbreviations used in text figures are listed below:

ba — basal angle
bua — buccal ampullae
cc — commissural canal (cephalic sensory canal)
elf — endolymphatic fossa
ep — epiphysial foramen
es — eye stalk
f — foramina at prefrontal wall
fca — foramen for carotid artery
fel — foramen for endolymphatic duct
fpo — foramen prooticum
frp — fossa for recti posterior
hmc — hyomandibular canal (cephalic sensory canal)
hmVII — foramen for hyomandibular branch of facial and palatine nerves
ioa — infraorbital ampullae
ioc — infraorbital canal (cephalic sensory canal)
kp — keel-process of basal cranii
ll — lateral line
mc — mandibular canal (cephalic sensory canal)
mpo — mandibular pit organs
pa — palatobasal plate
pcf — precerebral fossa
pf — prefrontal fontanelle
pfw — prefrontal wall
pop — postorbital process
psb — foramen for efferent of pseudobranchial artery
rp — rostral process
sf — subnasal fenestra
sn — subnasal stay
soa — supraorbital ampullae
soc — supraorbital canal (cephalic sensory canal)
tr — transbasal canal
III — foramen for oculomotor nerve
VI — foramen for abducent nerve

Comparative materials. *Centroscyllium fabricii*: ZMUC 185 (syntype), stuffed, Greenland; FSFL-0863d, 500 mm TL, female, northwestern Pacific; HUMZ 112509, 112510, 112520, 112531, 112559, 112561, 380–438 mm TL, 4 males and 2 females, Greenland.

C. granulatum: BMNH 1887.12.7.2 (holotype), 226 mm TL (caudal fin broken), male, Falkland (Malvinus) Is. (measured by A. C. Wheeler).

C. kamoharai: TMFE 128, 437 mm TL, female, Suruga Bay; HUMZ 95207, 95256, 367, 420 mm TL, 2 males, East China Sea; BSKU 26292, 26652, 26656, 26870, 28457, 28570, 221–411 mm TL, 3 males and 3 females, Okinawa Trough.

C. nigrum: HUMZ 110328, 110329, 373, 380 mm TL, 2 males, off California; FAKU 46337, 46339, 46347, 407–439 mm TL, 2 males and 1 female, off Chile; FRSKU-S1660, 385 mm TL, female, off Chile.

C. ornatum: ZSI 11665 (one of 3 syntypes), 115 mm TL, male, Bay of Bengal (now housed as BMNH; measured by A.C. Wheeler).

C. ritteri: SU-7185 (holotype), 415 mm TL, male, Misaki (now housed as CAS); USNM 51388 (paratype), ca. 35 cm TL, Misaki; HUMZ 77538, 408 mm TL, male, off Aomori; HUMZ 90742, 418 mm TL, male, off Muroran.

C. ruscosum: USNM 51585 (holotype), 214 mm TL, male, off Oahu Island; SU-8462 (paratype), 396 mm TL, male, off Oahu Island.

Centroscyllium excelsum sp. nov.

(New Japanese name: Oo-kasumi-zame)
(Figs. 1–3, Table 1)

Centroscyllium ritteri: Shirai, 1983: 48 (figure only).

Holotype. HUMZ 59470, 562 mm TL, mature male, Emperor Seamount Chain, 38°37′–49°59′N, 171°06′–170°00′E, 800–1,000 m deep, Apr. 13–May 17, 1977.

Paratypes. 9 mature males and 2 mature females, collected with holotype: male—HUMZ 69262, 558 mm TL; HUMZ 69264, 588 mm TL; HUMZ 69275, 588 mm TL (dissected); HUMZ 69276, 555 mm TL; HUMZ 69278, 605 mm TL; HUMZ 69280, 604 mm TL; CAS 64434, 524 mm TL; NSMT-P 30094, 618 mm TL; USNM 300576, 574 mm TL; female—HUMZ 68733, 534 mm TL; HUMZ 69265, 636 mm TL.

Other materials. 9 mature males, collected with type series: HUMZ 69267, 69268 (dissected), 69269–69274, 69277, 546–612 mm TL. 10 embryos from HUMZ 68733: male—HUMZ 113277, NSMT-P 30095, 91, 90 mm TL; female—HUMZ 113271–113276, 113278, NSMT-P 30096, 80–93 mm TL.

Diagnosis. An etmopterine species with lower jaw teeth similar to the upper in shape and arrangement; teeth with 2 to 4 lateral cusps; 1st dorsal fin very high, semicircular in shape, its height equal to or slightly larger than the base length; 1st dorsal spine prominently developed; 2nd dorsal spine originating well behind rear end of pelvic fin base, almost reaching apex of the fin; rear end of pectoral fin when laid back slightly anterior of 1st dorsal spine; interspace between 2nd dorsal fin and upper lobe of caudal fin equal to distance from posterior rim of orbit to 1st gill opening; dermal denticles conical with blunt tips, distributed sparsely, only on upper surface of head and trunk and proximal portion of both sides of pectoral fin; prefrontal wall (forming the ventral margin of prefrontal fontanelle) present with some foramina; subnasal stay and keel-process of basal cranii present; genio-coracoideus arising directly from coracoid; 1st and 2nd

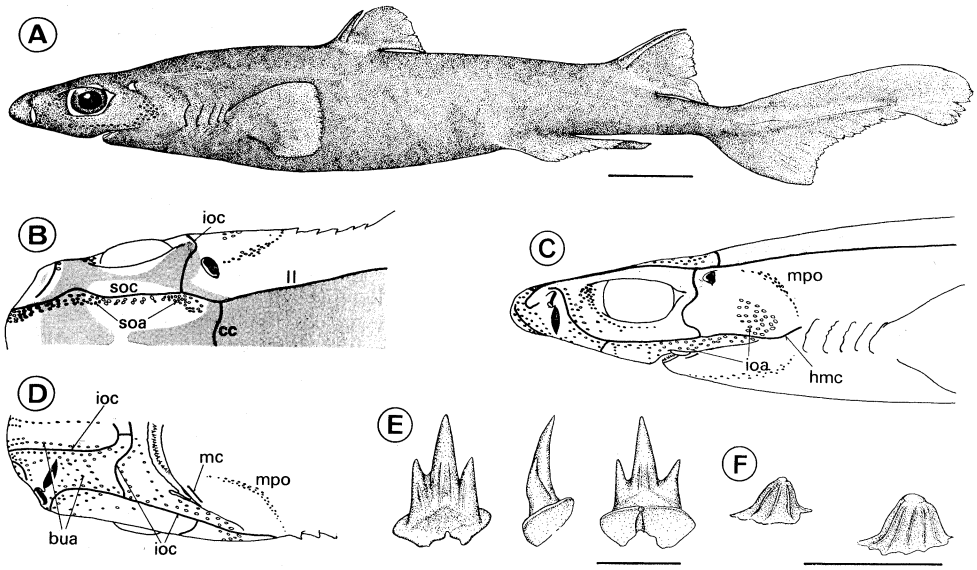

Fig. 1. *Centroscyllium excelsum* sp. nov., holotype (HUMZ 59470), male, 562 mm TL. A, lateral view; B, C and D, dorsal, lateral and ventral views of head respectively, showing sensory canal system (solid lines), ampullae of Lorenzini, pit organs, and distribution of dermal denticles (half tone); E, frontal (left), lateral (middle) and back views (right) of an upper jaw tooth from near the symphysis; F, dorsolateral views of dermal denticles on nape. Scale bar for A indicates 50 mm and those for E and F 1 mm.

interpharyngobranchiales only present; clasper with 3 basal cartilages and 3 spine-like terminal cartilages (claw, spur, and rhipidion).

Description. Proportional measurements are given in Table 1. Figures for paratypes are in parentheses. Head somewhat depressed, flattened above, its length 3.3 (3.2–3.6) in PCL. Snout obtuse anteriorly, its length 5.1 (4.5–5.1) in HL and preoral snout 2.7 (2.3–2.7) in HL. Trunk moderately stout, its depth at pectorals about 6 in PCL; distance from snout tip to cloaca about 1.2 times that from cloaca to end of caudal fin. Tail slender, fairly compressed; caudal peduncle without a longitudinal keel or precaudal pit. First dorsal fin located at center of body to caudal origin, with strongly elevated and evenly rounded upper margin; its height 1.1 (1.0–1.3) times the base length and 1.2 (1.0–1.2) in eye diameter. Interspace between dorsal fins slightly less than that between pectoral and pelvic fins. Second dorsal fin on the caudal peduncle, its origin (exposure of the spine) behind pelvic fin base by a distance equal to about one-half eye diameter; 2nd dorsal fin somewhat larger than the 1st, with slightly concave distal margin and elongate rear tip, its height 1.3 (1.0–1.3) times that of 1st dorsal fin and about equal to eye diameter. Each dorsal fin spine strongly developed, with a longitudinal groove; 1st spine nearly straight, not strongly oblique, its length of exposed part slightly shorter than 1st dorsal fin base; 2nd spine more oblique, weakly curved backward, almost reaching apex of 2nd dorsal fin; its length of exposed part slightly longer than height of the fin. Pectoral fin broad without angular corners, its length of anterior margin 2.3 (2.1–2.4) in HL. Pelvic fin moderate in size, with strongly rounded outer corner, its length 1.8 (1.5–2.4) times the base length. Caudal fin with obliquely truncate tip and a distinct subterminal notch; origin of the upper lobe behind rear end of 2nd dorsal base by a distance from posterior rim of orbit to 1st gill opening; length of upper caudal margin 2.9 (2.6–3.2) in PCL; lower lobe well developed, subtriangular, length of the margin 1.8 (1.8–2.2) in the upper.

Nostril large, slightly oblique, close to snout tip; anterior nasal flap triangular with pointed tip extending across nostril; distance from snout tip

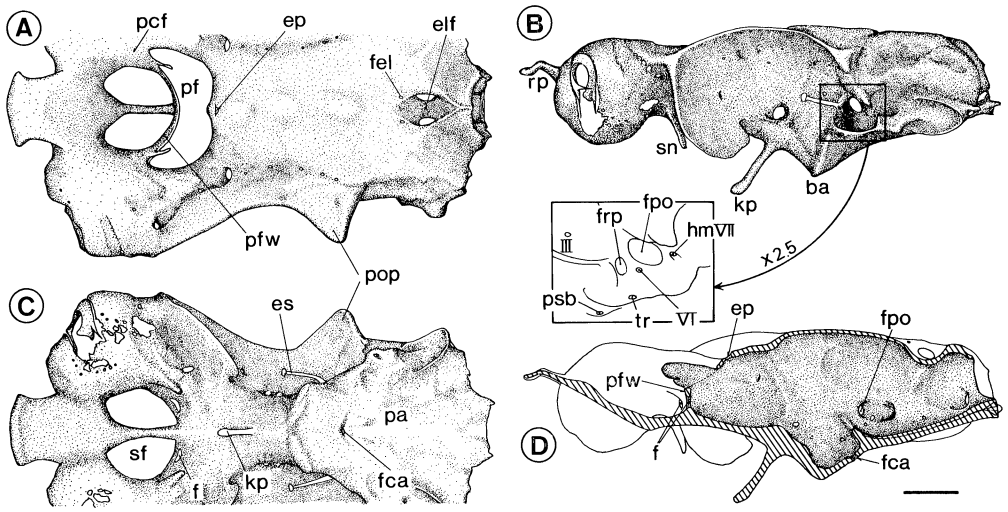

Fig. 2. Dorsal (A), lateral (B), ventral (C), and median (D, vertical section) views of the neurocranium of *Centroscyllium excelsum* sp. nov., paratype (HUMZ 69275), male, 588 mm TL. Scale bar indicates 10 mm.

to nostril 2.8 (2.4–3.3) in preoral snout. Orbit with deep anterior notch; horizontal eye diameter 1.5 (1 2–1.5) times snout length. Mouth wide, moderately arched, its anterior end below middle of eye; mouth width about equal to or slightly greater than preoral snout; upper and lower labial furrows at mouth corner, the upper forming a short preoral cleft anterointernally, the lower forming a groove posteriorly, reaching about half way toward 1st gill opening. Spiracle vertically ovate, at level of upper margin of orbit; vertical length of spiracle 4.1 (4.0–5.5) in eye diameter; distance between inner ends of spiracles about equal to preoral snout. Gill openings in horizontal series in front of pectoral fin base; 1st to 4th gill openings about equal in size, 5th somewhat smaller; length of the 1st 2.2 (1.8–2.2) in eye diameter, larger than vertical length of spiracle; interspace between openings nearly equal.

Jaw teeth minute in size, arranged quincuncially and similar in shape on both jaws; 51 (51–66) on upper and 49 (48–65) on lower jaw margins. Each tooth (Fig. 1E) on broad and bifid root, with an erect and sharp-pointed central cusp and a pair of short lateral cusps: up to 2 additional smaller cusps usually present in adult females, but very rare in adult males; 2 or 3 tooth series functional. Dermal denticles (Fig. 1F) conical and slightly inclined with blunt tip (nearly "granular" in shape) on small stellate bases, sparsely distributed in the following confined areas (Fig. 1B, C): dorsal side of head (except snout margin and supraorbital region), anterior and posterior ends of orbit (except its upper and lower margins), nape, trunk above lateral line (except interdorsal space in many specimens), and proximal portion of both sides of pectoral fin; very minute thorny denticles may be scattered on dorsal and pelvic fins, upper lobe of caudal fin, and ventral side of caudal peduncle below 2nd dorsal fin. Black dots, apparently luminous organs, arranged closely on ventral sides of head and trunk, also observed very sparsely on remainder of body. Cephalic sensory canals, ampullae of Lorenzini and pit organs in usual squalid arrangement (Fig. 1B–D). Number of spiral valves 7–9 (in HUMZ 68733, 69262, 69265, 69268, 69269, 69273, and 69275).

Neurocranium (Fig. 2) with a large nasal capsule and relatively long otic region. Rostral process (rp) short, thin, and broad, not supported ventrally; precerebral fossa (pcf) large, oval, lacking median process at its posterior margin; epiphysial foramen (ep) present; prefrontal fontanelle not enlarged to ventral surface of the cranium, interrupted by a low, arched and chondrified wall (prefrontal wall, defined here: pfw); some foramina (f) piercing prefrontal wall; subnasal stay (sn) at posterolateral edge of subnasal fenestra (sf). Keel-process of basal cranii (kp) long, slender, slightly before developed basal angle (ba); eye

Table 1. Proportional measurements (as percentage of total length) and counts of type series of *Centroscyllium excelsum* sp. nov.

	Holotype	Paratypes	
Sex	male	8 males	2 females
Total length (mm)	562	524–618	534, 636
Snout tip to:			
outer nostrils	3.0	2.6– 3.4	3.0, 3.3
eye	4.4	4.5– 5.0	4.8, 5.0
mouth	8.4	8.0– 8.7	7.9, 8.8
1st gill-opening	17.7	17.1–19.2	17.9, 18.9
pectoral origin (HL)	22.6	20.7–22.9	21.9, 22.5
pelvic origin	50.5	50.4–52.7	52.5, 54.9
1st dorsal origin	33.8	34.2–35.4	35.0, 35.8
2nd dorsal origin	61.8	60.5–64.0	63.0, 63.9
upper caudal origin (PCL)	74.4	73.4–76.9	74.7, 75.6
lower caudal origin	70.5	69.6–74.2	71.5, 72.6
Interspace between:			
pectorals and pelvics	24.6	24.5–27.2	26.3, 29.6
pelvics and lower caudal	12.2	11.8–14.2	10.3, 12.6
1st and 2nd dorsals	23.4	22.2–23.9	22.2, 24.9
2nd dorsal and upper caudal	7.7	7.3– 8.0	7.2, 8.6
Nostrils:			
distance between inner corners	4.6	4.4– 5.1	4.9, 5.0
Mouth:			
width	8.5	8.9–10.3	9.6, 10.1
Gill-opening length:			
1st	3.0	2.5– 3.1	2.8, 3.1
3rd	3.0	2.5– 3.1	3.1, 3.2
5th	2.8	2.4– 2.9	2.8, 3.1
Eye:			
horizontal diameter	6.6	5.3– 6.3	6.1, 6.3
1st dorsal fin:			
length of base	4.8	4.6– 5.3	4.5, 5.0
height	5.3	5.0– 6.1	5.3, 5.6
length of spine	4.2	3.0– 3.9	3.0, 3.8
2nd dorsal fin:			
length of base	4.8	4.5– 5.6	4.9, 5.7
height	6.9	5.5– 6.5	5.7, 6.0
length of spine	7.2	6.2– 6.8	6.3, 6.7
Pectoral fin:			
length of base	4.0	4.1– 5.3	5.0, 5.2
length of anterior margin	9.8	9.2–10.3	9.8, 10.3
Pelvic fin:			
fin length	13.2	11.5–13.4	12.5, 12.9
length of base	7.2	5.1– 7.8	5.5, 6.2
Caudal fin:			
length of upper lobe	26.0	23.9–27.9	25.2, 25.7
length of lower lobe	14.1	11.7–13.3	13.5, 13.7
Number of teeth:			
upper	51	52–66	51, 62
lower	49	48–65	49, 54
Number of vertebrae:			
monospondylous	42	42–44	42, 44
precaudal diplospondylous	21	17–20	17, 18
precaudal	63	59–64	60, 61
caudal	29	29–31	30, 31
total	93	90–94	91

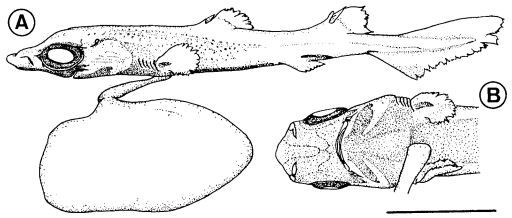

Fig. 3. Embryo of *Centroscyllium excelsum* sp. nov., HUMZ 113272, from left uterus of HUMZ 68733, 90 mm TL, female. A, lateral view; B, ventral view of head. Scale bar indicates 2 mm.

stalk (es) chondrified to the distal end, with an extreme disk, rectus muscles (except for recti posterior) arising on the basal part of eye stalk; a deep fossa for origin of recti posterior (frp) at interspace of eye stalk and foramen prooticum (fpo); abducent nerve with a separate foramen (VI); hyomandibular branch of facial nerve and palatine nerve with a shared foramen (hmVII); endolymphatic fossa (elf) relatively wide, spindle-shaped, with foramen for endolymphatic duct (fel) at anterolateral margin; supraotic shelf absent; palatobasal plate (pa) wide with single foramen for carotid artery (fca).

Other internal characters (skeletons and musculature) basically similar to those of usual etmopterine condition (see Shirai and Nakaya, in press). Mandibular arch relatively long, not strongly concave on outer side; palatoquadrate with long orbital and simple otic processes; genio-coracoideus not paired, directly arising from frontal surface of coracoid symphysis; suborbitalis originating from lower margin of foramen for optic nerve, inserted in part onto labial and its adjacent tissues, and the remainder to anterior end of posteroventral portion of adductor mandibulae by a short tendon; labial cartilages comprising short upper and oar-shaped lower pieces. First and 2nd interpharyngobranchiales present, but the 3rd (between 3rd and 4–5th pharyngobranchial cartilages) absent; a series of minute gill rakers on ceratobranchial and epibranchial of each arch; pharyngeal teeth absent. Three basal cartilages in pectoral fin. Clasper cartilages articulated with distal end of pelvic metapterygium by a beta cartilage and 3 basals; claw strongly curved externally, sharply pointed, spur and rhipidion also spine-like; ventral terminal cartilage subtriangular, flattened, shallow trough-like. Each dorsal fin with prespinal radials and a postspinal ray. Vertebral numbers: monospondylous 42 (42–44), precaudal diplospondylous 21 (17–20), precaudal 63 (59–64), caudal 29 (29–31), and total 92 (90–94); last monospondylous vertebra with perfect haemal arch.

Color in formalin: Dusky brown above, darker below; no distinct markings on head, pectoral fin, precaudal part or caudal fin (though small black dots are gathering at these areas: see above). Distal margin of each fin bleached out in some specimens; interorbital region without white spot, and upper margin of orbit whitish.

Distribution. *Centroscyllium excelsum* is collected from the Emperor Seamount Chain, central North Pacific, around 38–50°N, 170–171°E, in 800–1,000 m deep.

Biological notes. All of our trawled specimens of *C. excelsum* (524–636 mm TL) are mature, judging from their claspers or uteri. *C. excelsum* seems to be a relatively large species in the genus *Centroscyllium*. One of the female specimens (HUMZ 68733) contained 10 embryos, 5 (1 male and 4 females) in each uterus. The embryos (Fig. 3) are 80–93 mm TL with large external yolk sacs. They possess a semicircular 1st dorsal fin and similar fin positions to those of the adults, but do not have any dermal denticles. Body color is light brownish gray above and dark brown below, with intense black markings around the mouth, on the lower side of the pectoral fin, precaudal region and caudal fin. Black dots (luminous organs) are arranged on the darkly pigmented portions and along the lateral line. The posterior end of the lateral line is opened for a short distance with a black marking along the lower edge of the groove.

In all 7 specimens dissected for counts of intestinal valves, the stomachs were empty, although several kinds of small fish scales, bones, and eye balls were found in their intestines.

Etymology. From the Latin adjective *excelsus* (high or elevated) in reference to the unique configuration of the first dorsal fin.

Discussion

Centroscyllium excelsum is distinguished from other members of the genus *Centroscyllium* mainly by a) dermal denticles with blunt tips

found only on dorsal surface of head and trunk, and b) a very high and semicircular-shaped 1st dorsal fin.

All adult congeners, except for *C. kamoharai*, have closely arranged dermal denticles on the body including the ventrolateral surface. However, *C. kamoharai*, one of the most poorly known species in the genus (Compagno, 1984; Nakaya, 1984), is characterized by the loss of body denticles. Abe (1966) noted that, on the basis of three mature female type specimens, dermal denticles are "almost absent on body, and scattered on all fins" in his original account of *C. kamoharai*. We could examine many adult male and female specimens of *C. kamoharai* from other sources, but all of them lack dermal denticles on the body. *C. ruscosum*, which has been synonymous with *C. nigrum* since Garman (1913), is also known to be almost naked in the juvenile holotype (214 mm TL), but its paratype (396 mm TL) is covered by thorny denticles on the whole body. Although we do not refer to the specific status of this species here, the naked condition in the holotype is considered to be a juvenile feature in this species as noted in Gilbert's (1905) original description.

The second character, the 1st dorsal fin shape, distinguishes *excelsum* from its congeners (Fig. 4), except for *granulatum* in which the 1st dorsal fin shape is unknown owing to considerable damage to the holotype (Buckhardt, 1900; A. C. Wheeler, pers. comm.). The height of the 1st dorsal fin is equal to or slightly larger than the base length (1.0–1.3 times the base) in *excelsum*, but is shorter (0.6–0.8 times) in the others. We consider the morphological difference of the 1st dorsal fin is effective for their identification, because it hardly changes with growth in well-known congeners, *fabricii* and *ritteri*.

Other additional characters available in their taxonomy are: c) 2nd dorsal spine arising behind rear end of the pelvic fin base, almost reaching apex of the fin (arising at level of rear end of pelvic fin base in *ornatum*, *granulatum*, and *kamoharai*), and 2nd dorsal spine relatively short (not reaching the apex) in *fabricii*, *granulatum*, *kamoharai*, and *ritteri*; d) short caudal peduncle, interspace between 2nd dorsal fin and upper caudal lobe equal to the distance from posterior rim of orbit to 1st gill opening (equal to that to pectoral origin in *granulatum*); e) eye stalk chondrified to its distal end (chondrified only proximally in *nigrum*: Shirai and Nakaya, in press); and f) prefrontal wall present (absent in *fabricii*, *kamoharai*, *nigrum*, and *ritteri*: Shirai and Nakaya, in press).

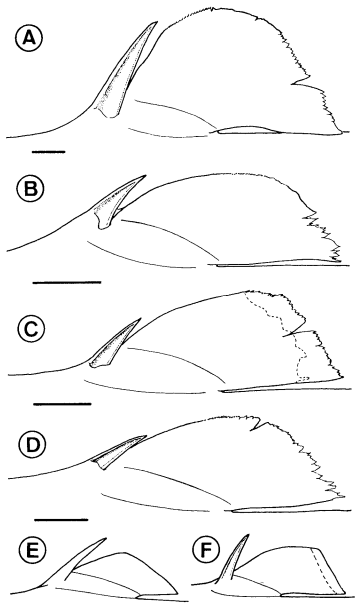

Fig. 4. First dorsal fin in *Centroscyllium* species. A, *C. excelsum* sp. nov., HUMZ 59470, holotype; B, *C. fabricii*, HUMZ 112561; C, *C. ritteri*, HUMZ 77538; D, *C. kamoharai*, HUMZ 95207; E, *C. ornatum* (after Compagno, 1984); F, *C. nigrum* (after Garman, 1899). Scale bars indicate 10 mm.

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and *C. ornatum*, and to Dr. Gregor M. Cailliet (Moss Landing Marine Laboratories) for his cooperation in carrying the holotype of *C. ritteri* to us.

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天皇海山で採集されたカスミザメ属魚類の 1 新種

白井　滋・仲谷一宏

天皇海山海域で採集されたカスミザメ属の新種，オオカスミザメ (*Centroscyllium excelsum*) を記載した．本種は第一背鰭が非常に高くその外縁が円いこと，鱗が体の側・腹面にはないが，頭部から軀幹部にかけての背面に分布すること，第二背鰭棘が腹鰭基底よりまったく後方に位置することなどで他のカスミザメ属魚類と容易に区別される．雌の 1 個体からは全長 90 mm 前後の胎仔 10 個体が得られたが，これらは尾柄部に明瞭な暗色斑をもち，側線管の末端部が溝状に開くことなどで成体と異なっていた．

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